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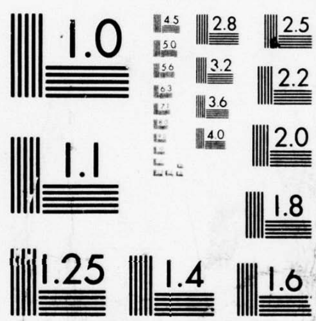

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STUDY OF GEOMAGNETIC STORMS AND SOLAR FLARES IN THE YEARS OF INCREASING SOLAR ACTIVITY, CYCLES 19 AND 20 (1955-1957, 1965-1968)

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SCIENTIFIC REPORT NO. 3

31 OCTOBER 1978

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19 REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 18 AFGL-TR-78-0267
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER: 14
4. TITLE (and Subtitle): 6 Study of Geomagnetic Storms and Solar Flares in the Years of Increasing Solar Activity, Cycles 19 and 20 (1955-1957, 1965-1968),
5. TYPE OF REPORT & PERIOD COVERED: Scientific ~~Report No.~~ 3
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): 10 H. W. Dodson-Prince, E. R. Hedeman, O. C. Mohler
8. CONTRACT OR GRANT NUMBER(s): 15 F 19628-76-C-0240
9. PERFORMING ORGANIZATION NAME AND ADDRESS: McMath-Hulbert Observatory of The University of Michigan, 895 Lake Angelus Rd., Pontiac, Mi. 48055
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 61102F, 16 2311G1AB 17 G1
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts 01731, Monitor/ M. A. Shea/ PHG
12. REPORT DATE: 11 31 Oct[redacted] [redacted]78
13. NUMBER OF PAGES: 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 12 39p.
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Geomagnetic Storms
Solar Flares
Solar-Terrestrial Physics

sub p

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Solar circumstances prior to the 245 geomagnetic storms with maximum values of 3-hourly K_p greater than or equal to 5 in the years 1955-1957 and 1965-1968 have been evaluated. The years studied were those of increasing activity in solar cycles 19 and 20. To assist in this study, a Comprehensive Flare Index based on the flare's Hα, ionizing, and radio frequency radiation has been used. Of the 245 storms in the seven years studied 62% were considered to be flare-associated, 30% were primarily → next page

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H-alpha 223650

sequential, and only 8% remained as "problem" cases. Most of the severe storms were associated with flares. Sequential storms were primarily of moderate severity.

Flares that were found to have been followed by geomagnetic storms were, in general, important solar events. For only 5 storm-associated flares (with complete data) was the Hα importance less than 2 and the Comprehensive Index also less than 6. A preponderance of the storm-associated flares occurred in the western hemisphere of the sun but the most severe storms were associated with flares strongly concentrated toward the central part of the solar disk. The most important flares tended to be associated with the most severe storms. Flare criteria that include ionizing and radio frequency emissions as well as optical data apparently assist in the recognition of flares associated with subsequent geomagnetic storms.

STUDY OF GEOMAGNETIC STORMS AND SOLAR FLARES IN THE YEARS OF INCREASING SOLAR ACTIVITY, CYCLES 19 AND 20 (1955-1957, 1965-1968)

I. Introduction

Since 1948 the McMath-Hulbert Observatory has kept in close juxtaposition detailed records of observed solar activity, ionospheric disturbances, and geomagnetic storms. For each geomagnetic disturbance it has been possible to evaluate the prior flare and radio frequency events, the locations and activity levels of individual plages, and the time patterns of the geomagnetic storms. These intercomparisons of solar activity and geomagnetic disturbance covering almost three decades have led to a deep respect for the difficulty of efforts to explain unambiguously disturbances in the earth's magnetic field in terms of observed solar phenomena.

It is well known that geomagnetic storms can be divided into two groups, 1) "sequential" or approximately 27-day recurrent storms, and 2) the so-called sporadic, or non-sequential disturbances. In addition, there are certain storms that are border line cases for both of these categories. In recent years there has been great progress in the association of sequential storms with solar wind streams emanating from long lasting "coronal holes" with their weak coronal emission and open magnetic field lines. (Nolte et al, 1976). Sporadic storms are generally thought to be flare-associated. The purpose of this investigation is to evaluate anew the types of geomagnetic storms during the years of increasing activity in solar cycles 19 and 20 and to try to determine the degree of association between individual flares and subsequent geomagnetic disturbance.

For this study, all geomagnetic storms reported by the world wide network of geomagnetic stations in the seven years 1955-1957 and 1965-1968 have been evaluated on the basis of the severity and duration of the geomagnetic disturbance. For purposes of comparison, storms with maximum values of the 3-hourly K_p as great as 7, 8, and 9 have been considered as "severe." Storms with maximum K_p of 5 and 6 have been classified as "moderate." Weaker disturbances with maximum K_p of only 4 or less have been omitted from the survey. Solar records and reports have been searched in efforts to recognize the solar phenomena apparently responsible for each storm for which the 3-hourly K_p became as great as 5.

II. Procedure

A. Derivation of Comprehensive Flare Index (CFI).

To assist in the evaluation of the relationships between flares and geophysical effects, a Comprehensive Flare Index (CFI) based on the radio frequency and ionizing radiation of a flare as well as on its optical importance has been developed (Dodson and Hedeman, 1971). The index is determined by five components which, when taken sequentially, constitute a crude profile of the electromagnetic radiation of the flare. The sum of the five components gives the Comprehensive Flare Index. The five quantities that comprise the flare profile and Comprehensive Index are described below.

1. Importance of ionizing radiation as indicated by time-associated Short Wave Fade or Sudden Ionospheric Disturbance; (scale 1-3)
   Note: Direct measurement of X-ray flux, if available, would be preferable to this indirect indication of its magnitude. The correlation, however, between SWF importance and X-ray flux appears to be gratifyingly close. (Dodson and Hedeman, 1975)
2. Importance of Hα flare (scale 0-3)
3. Magnitude of ~10 cm flux (characteristic of log of flux in units of $10^{-22} Wm^{-2} (C/S)^{-1}$.
4. Dynamic spectrum (scale 0-3; Type II = 1, Continuum = 2, Type IV with duration >10 min. = 3).
5. Magnitude of ~200 MHz flux: (characteristic of log of flux in units of $10^{-22} Wm^{-2} (C/S)^{-1}$).

The Comprehensive Flare Index can be determined for any flare for which the needed observations exist. Values of the Index have been derived and published (Dodson and Hedeman, 1971 and 1975) for all flares in the years 1955-1974 that could be considered as "major" on the basis of any <u>one</u> of the following criteria:

Shortwave fade or SID, importance ≥ 3

Hα flare, importance ≥ 3

10 cm flux $\geq 500 \times 10^{-22} Wm^{-2} (C/S)^{-1}$

Type II burst

Type IV radio emission, duration >10 minutes

In the years 1955-1974 there were 1666 such "major" flares and the values of the Comprehensive Flare Index for these flares ranged from 1 for subflares with Type II bursts to 17 for flares that were great in all aspects. Flares with Comprehensive Indices ≥ 11 comprised 13 percent of the so-called "major" flares.

For the year 1967, the Comprehensive Index was derived for all flares with Hα importance ≥ 1. Of the 515 such flares in 1967, <2 percent had comprehensive indices ≥ 11 and only 12 percent had values from 6-10. Flares with Comprehensive Indices ≥ 6 were about as frequent as flares with Hα importance 2 and 3 but the groups of "above average" flares selected by these two different criteria had only about half the events in common.

B. Statistical Relationships between "Major" Flares and Geomagnetic Disturbance.

Mean values of superposed daily ΣK_p geomagnetic indices for 6 days before and 6 days after the occurrence of major flares, as above defined, have been derived for the years 1957-1963 and 1966-1969. For this study the "major" flares were divided into three groups based on values of the Comprehensive Flare Index, viz. >10, 6-10, <6. (See Figures 1 and 2).

According to this investigation, for the years studied in both cycles 19 and 20, the circumstances are, in general, definite and consistent. For "major" flares with Comprehensive Flare Indices >10, there is a well defined, relatively large increase in the mean values of superposed ΣK_p indices on day 1, 2, and 3, following the day of flare occurrence. For "major" flares with values of the Comprehensive Index 6-10, there is only a small rise, or none, in the mean values of ΣK_p on the days following the flares. However, for even "major" flares with Comprehensive Indices <6, the mean values of ΣK_p do not increase. These results indicate a clear statistical association between geomagnetic disturbance and the truly great flares with strong ionizing and radio frequency emission, but deny such associations for flares without these characteristics. This work suggests that assignment of geomagnetic storm-causation to minor or only average flares is seldom justified.

III. Study of 245 Principal Geomagnetic Storms: 1955-1957 and 1965-1968.

A. Classification of the Geomagnetic Storms.

With the foregoing statistical studies for guidance, an attempt has been made to evaluate solar circumstances prior to each of the 245 principal geomagnetic storms in the years 1955-1957 and 1965-1968. All storms for which the 3-hourly K_p became as great as 5 have been considered in the investigation. Geomagnetic disturbances with maximum 3-hourly K_p of only 4 have been omitted. The times covered by the study include the years of increasing activity in solar cycles 19 and 20, years in which sporadic geomagnetic storms can be expected to occur with high frequency.

In this work we have recognized three principal catagories of storms. viz. flare-associated, sequential, and "problem."

We have considered as flare-associated those storms that were preceded within the prior 16 to 84 hours by flare-events that were, in our judgment, above average in either Hα, ionizing, or radio frequency emission. Storms without apparently suitable prior flares but which occurred in approximately 27-day recurrence patterns have been classified as sequential. The "problem" storms are the non-sequential disturbances for which seemingly appropriate prior flares were not observed. In addition, we often have felt obliged to indicate that certain storms could be either flare associated or sequential. In such cases, we have used the double term "flare-sequential" or "sequential-flare" to point out the uncertainty. The first member of the double term represents our best judgment in each case. During times of great flare activity, a single geomagnetic storm may be preceded by more than one apparently appropriate storm-causing flare. In such instances the storm has been classified as "flare-ambiguous." This situation was so usual in 1956 and 1957 in cycle 19 that certain of the reported results for these years may be less reliable than corresponding data for the less active years in cycle 20.

Summaries of the data relating to our evaluations of the 245 principal geomagnetic storms in the years 1955-1957 and 1965-1968 are given in Tables 1 and 2 of this report.

For the years 1955-1957, in the very active cycle 19, 71 percent of the 138 geomagnetic storms were classified by us as flare associated; 22 percent as sequential, and only 9 storms, or 7 percent, remained as "problem" storms. In less active cycle 20, the results are different. For the years 1965-1968, with data available from a nearly complete flare patrol, only 53, or 50 percent, of the 107 storms have been considered as probably flare associated and 44 (41 percent) of the storms were seemingly sequential. Fewer than 10 percent of the storms studied were considered to be "problem" cases (see Table 3 and Figure 3). For the combined data of 1955-1957 and 1965-1968, 62 percent of the storms were considered to be flare associated, 30 percent sequential, and only 8 percent remained as "problems."

Although the principal, well defined, sequential storms usually occur during the declining years of the sunspot cycle, the present investigation indicates that lesser series of approximately 27-day recurrent disturbances without apparently suitable prior flares also took place during the years of increasing solar activity in cycles 19 and 20. In comparison to the sequential storms of post-maximum years, these apparent sequences in the early part of the cycle are short, show marked variation in severity from storm to storm, and have time differences of 26 to 29 days. They often are not conspicuous on plots of K_p but usually can be recognized easily in the C_9 charts. Do observations of coronal holes during the current years of increasing activity for cycle 21 tend to confirm these aspects of apparently sequential geomagnetic disturbances in corresponding years of the two prior cycles?

B. Severity of the Geomagnetic Storms.

For each of the years studied (1955-1957, 1965-1968), flares apparently were associated with a very high percentage of the most severe storms. This result is in accord with that reported by Bell (1963). As the maximum 3-hourly value of K_p for the respective storms diminishes from 9 to 5, the number of storms apparently caused by prior flares increases, but the percentage of storms in the respective categories caused by by flares diminishes (see Table 3 and Figure 3). For the years studied, the percentages of flare-associated storms ranged from 100 percent for storms with maximum K_p equal to 9 to only 50 percent for storms with maximum K_p of only 5. Of the 245 geomagnetic storms evaluated for the years studied, 152, or 62 percent, were considered to be primarily flare-associated.

IV. Characteristics of Flares Associated with Geomagnetic Storms: 1955-1957 and 1965-1968.

In the years studied, the flares that were found to have been followed by geomagnetic storms (maximum 3-hour $K_p \geq 5$)

were, in general, important solar events. Fifty-four of the flares (36 percent) were of Hα importance 3 or had a Comprehensive Flare Index ≥11. For only 5 of the storm associated flares (with complete data) was the Hα importance less than 2 and the Comprehensive Index also less than 6. These results, of course, reflect the point of view with which the evaluations were conducted. Minor or merely average flares were not considered to be storm-producing events. Nevertheless, the study makes clear that, in spite of the overall complexities of the problem, a large proportion (86 percent) of the non-sequential storms in the years studied were indeed preceded within apparently appropriate time intervals by the occurrence of flares that were well above average in either optical, ionizing, or radio frequency emissions (i.e. Hα importance ≥ 2 and/or CFI ≥6).

The location of the flare on the solar disk apparently influences both the probability of storm-occurrence and its severity. The flares that have been associated in this study with subsequent storms were located from east limb to west limb on the solar disk. More of the storm-causing flares were in the west than in the east (59 percent versus 41 percent) and tended to maximize between the central meridian and 60° west longitude. Only 22 percent of the storm-associated flares in the years studied occurred within 30° of the respective solar limbs (see Figure 4).

If the flares are divided according to the severity of the storms with which they are associated, viz. severe (3-hourly K_p = 7, 8, 9) and moderate (3-hourly K_p = 5, 6), the western preponderance continues in each group, but a strikingly different distribution pattern becomes evident. The flares associated with severe storms cluster towards the central part of the solar disk. This finding is in accord with prior studies (Newton, 1951; Dodson and Hedeman, 1958; Bell, 1961). Flares associated with moderate storms show two maxima located roughly 20°-60° east and west of the Central Meridian (see Figure 4).

This diagram illustrates also the $H\alpha$ importance of the flares. The severe storms were associated with a much higher proportion of flares of $H\alpha$ importance 3 (42 percent) than were the moderate storms (16 percent).

V. Frequency of Storm-Association with Flares in Different Categories.

The foregoing detailed comparisons of geomagnetic disturbance and solar activity have made it possible to determine, for certain of the years studied, the degree to which great flares were followed by the onset of geomagnetic storms. It seems wise to limit such consideration to the years 1965-1968 with their more complete data. For the years 1955-1957 a frequent lack of $H\alpha$ flare-patrol or radio-frequency data coupled with the many ambiguous flare identifications suggest that the cycle 19 cases be omitted from this part of the report.

According to the data for 1965-1968, the association was very close between the occurrence of truly great flares and the onset of subsequent geomagnetic disturbance, especially for flares west of the central meridian. In 1965-1968 there were 20 flares of $H\alpha$ importance 3, 11 in the east and 9 in the west. Only 36 percent of the flares of importance 3 in the east were storm associated, but in the west, 89 percent of the flares were followed by geomagnetic storms. For all flares of importance 3, the storm association was 60 percent.

In these same years there were 25 flares with Comprehensive Flare Indices ≥ 11 of which 68 percent were storm associated. For the 14 flares in this group that took place in the west, 79 percent were followed by geomagnetic disturbance.

If flares of importance 3 and/or flares with Comprehensive Indices ≥ 11 are considered together, 37 such "great" flares can be identified for the years 1965-1968. Of this larger groups of flares, 37 percent in the east and 78 percent in the west were followed by geomagnetic storms. In the four years, 1965-1968, only four of the "great" flares (as here defined) which were west of the central meridian failed to cause a geomagnetic storm.

Consideration of these "greatest" flares in 1965-1968 leads, however, to only 21 geomagnetic storms, whereas Table 3 indicates that there were 53 probably flare-associated storms in that time interval. To account for the remaining storms it is necessary to consider the role of the much more frequent lesser flares.

In the years 1965-1968, there were 149 flares of Hα importance 2. Twenty-seven or only 18 percent of these flares have been associated with subsequent geomagnetic storms (see Table 2). Together, flares of Hα importance 2 or 3 accounted for 39 of the 53 flare-associated storms in the years studied. About one-fourth of the storms were apparently initiated by flare events with only such average chromospheric aspects as Hα importance 1 or "subflare" classifications.

With respect to this problem we have found a certain degree of help from consideration of that group of flares that we have called "major" as defined in Part II of this report. "Major" flares are those flare events that satisfied at least <u>one</u> of five criteria representing exceptional circumstances in either optical, ionizing, or radio frequency emission. In the years 1965-1968 there were 269 such "major" flares and their Comprehensive Flare Indices ranged from 1 to 17. Of the 53 flare-associated storms in 1965-1968 there were only five cases (with complete data) for which the apparently causative flares did not qualify as "major". Thus, approximately 90 percent of the apparently flare-associated storms in the years studied followed flares that can be classified as "major." Although "major" flares can account for a gratifyingly high proportion of flare-associated storms, the percentage of "major" flares followed by storms with $K_p \geq 5$ remains relatively low, approximately 22 percent.* In evaluating the storm-producing chances of "major" flares, it should be noted that no storms in the years 1965-1968 were apparently caused by "major" flares for which the Comprehensive Flare

* In this calculation all "ambiguous" flares have been included.

Index was less than 4. Furthermore, the percentage of "major" flares associated with subsequent geomagnetic storms steadily increased as the Comprehensive Flare Index (CFI) became larger (see Figure 5). For the years here studied, the proportion of "major" flares followed by geomagnetic storms ($K_p \gtrsim 5$) increased from zero for values of the Comprehensive index $\lesssim 4$ to 100 percent for values of the Comprehensive Index >13.

The occurrence of a flare-associated geomagnetic storm, and its severity, apparently reflect a complex interplay between the greatness of the flare on the sun, its closeness to the central meridian, and the propagation circumstances in the interplanetary medium. The recognition of a flare that is unusually great in either ionizing, optical, or radio frequency emission, and the use of a comprehensive flare index that attempts to evaluate the overall greatness of the electromagnetic spectrum of a flare, apparently constitute helpful techniques in anticipating the probable post-flare geomagnetic disturbance.

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CAPTIONS FOR FIGURES

<u>Figure 1</u>

Mean Values of ΣK_p for Six Days before and Six Days after the Occurrence of "Major" Flares with Comprehensive Indices >10, 6-10, and 1-5 respectively, for Six Time Intervals, 1957-1969.

<u>Figure 2</u>

Mean Values of ΣK_p for Six Days before and Six Days after the Occurrence of "Major" Flares with Comprehensive Indices >10, 6-10, and 1-5 respectively, for Solar Cycle 19 and Solar Cycle 20 (To 1969 inclusive).

<u>Figure 3</u>

Most Probable Cause and Severity of 245 Geomagnetic Storms during Years of Increasing Activity: Solar Cycles 19 (top) and 20 (bottom).

<u>Figure 4</u>

Central Meridian Distance and Importance of 147 Flares Associated with Storms of Different Severities.

<u>Figure 5</u>

Number and Percent of "Major" Flares with Different Values of the Comprehensive Flare Index (CFI) Associated with Geomagnetic Storms with Maximum 3-Hourly $K_p \geq 5$, 1965-1968.

Mean Values of $\sum Kp$ for Six Days before and after the Occurrence of "Major" Flares with Different Values of the Comprehensive Flare Index.

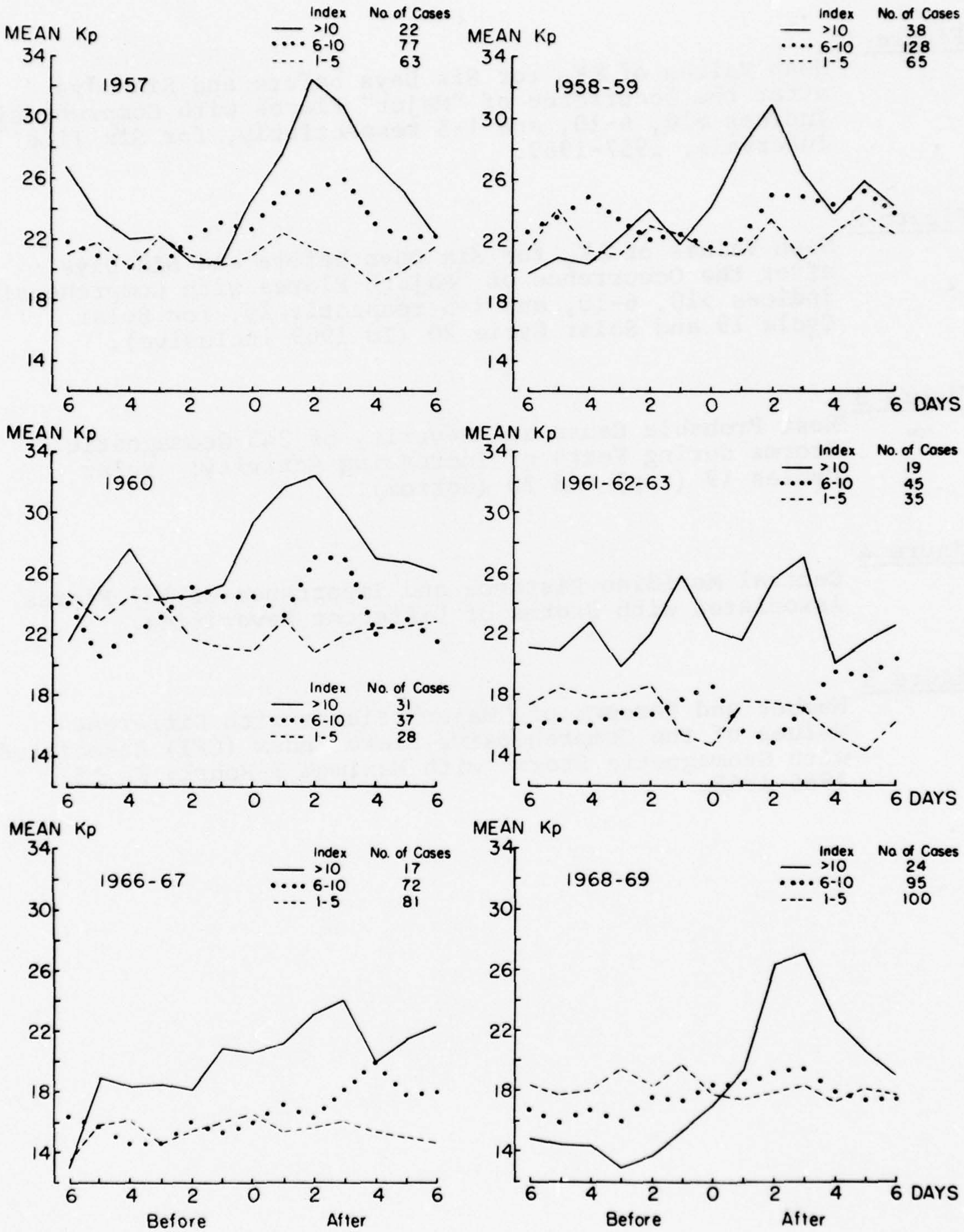
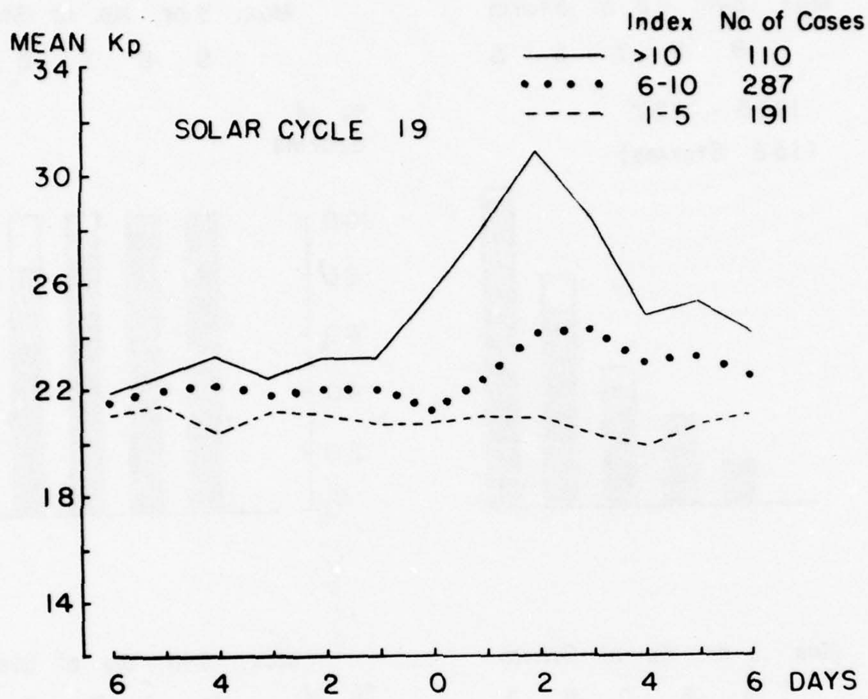


Fig. 1

Mean Values of $\sum Kp$ for Six Days before and after the Occurrence of "Major" Flares with Different Values of the Comprehensive Flare Index, Solar Cycle 19 and 20



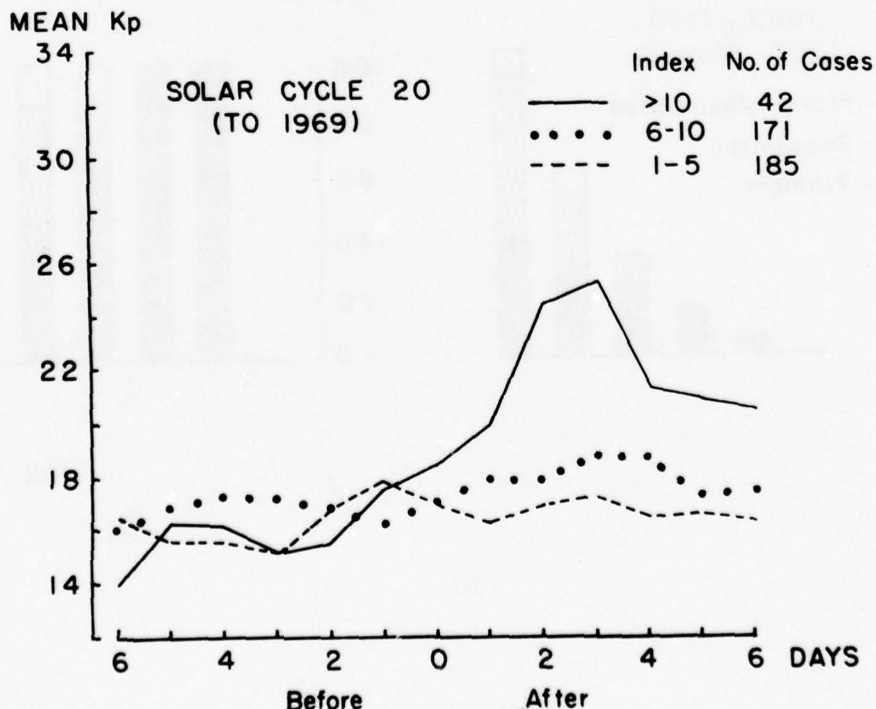


Fig. 2

Number and Percent of Geomagnetic Storms by Severity and Classification

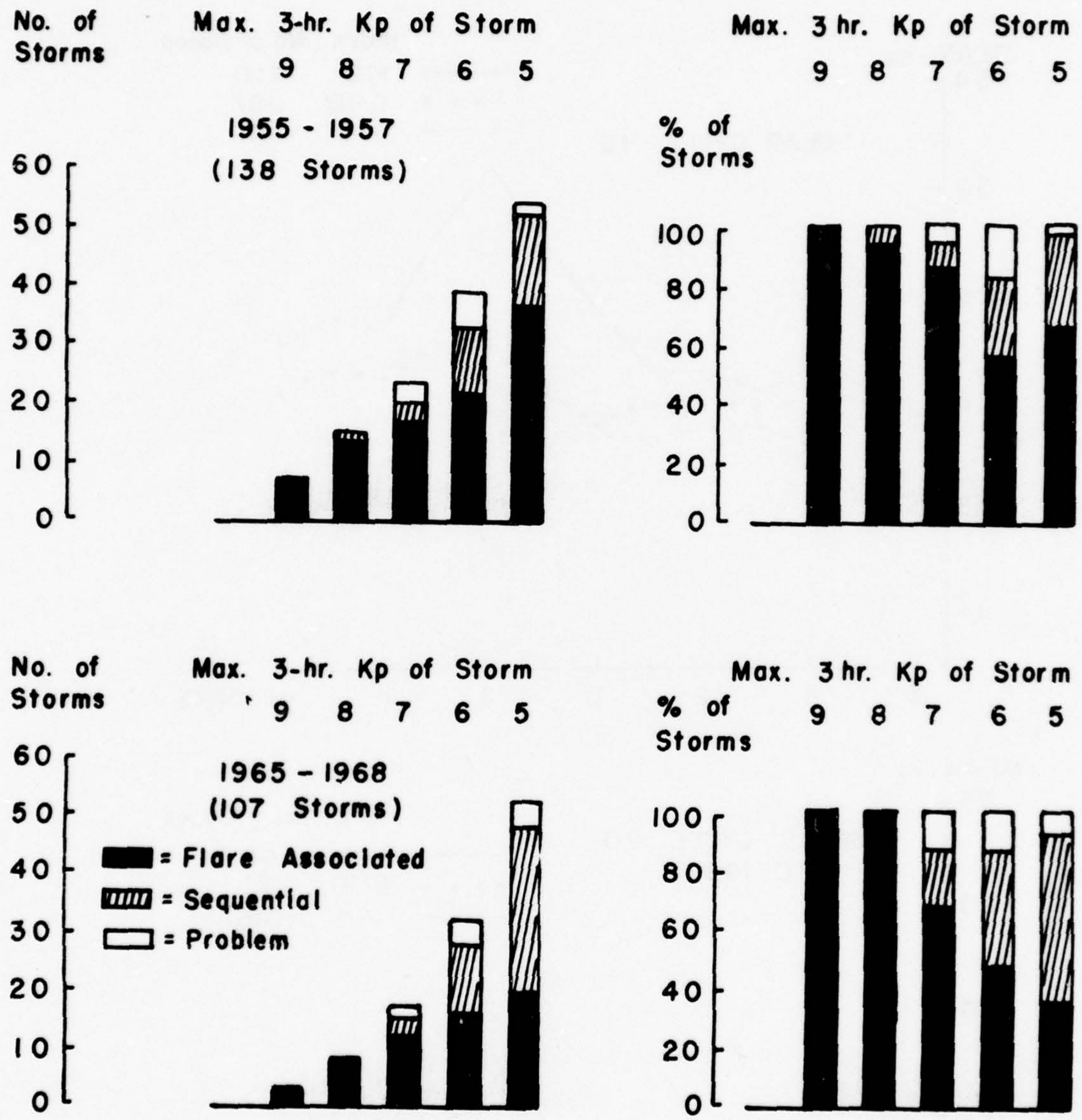


Fig. 3

Central Meridian Distance and Importance of Flares Associated with Geomagnetic Storms of Different Severities; 1955-57 and 1965-68.

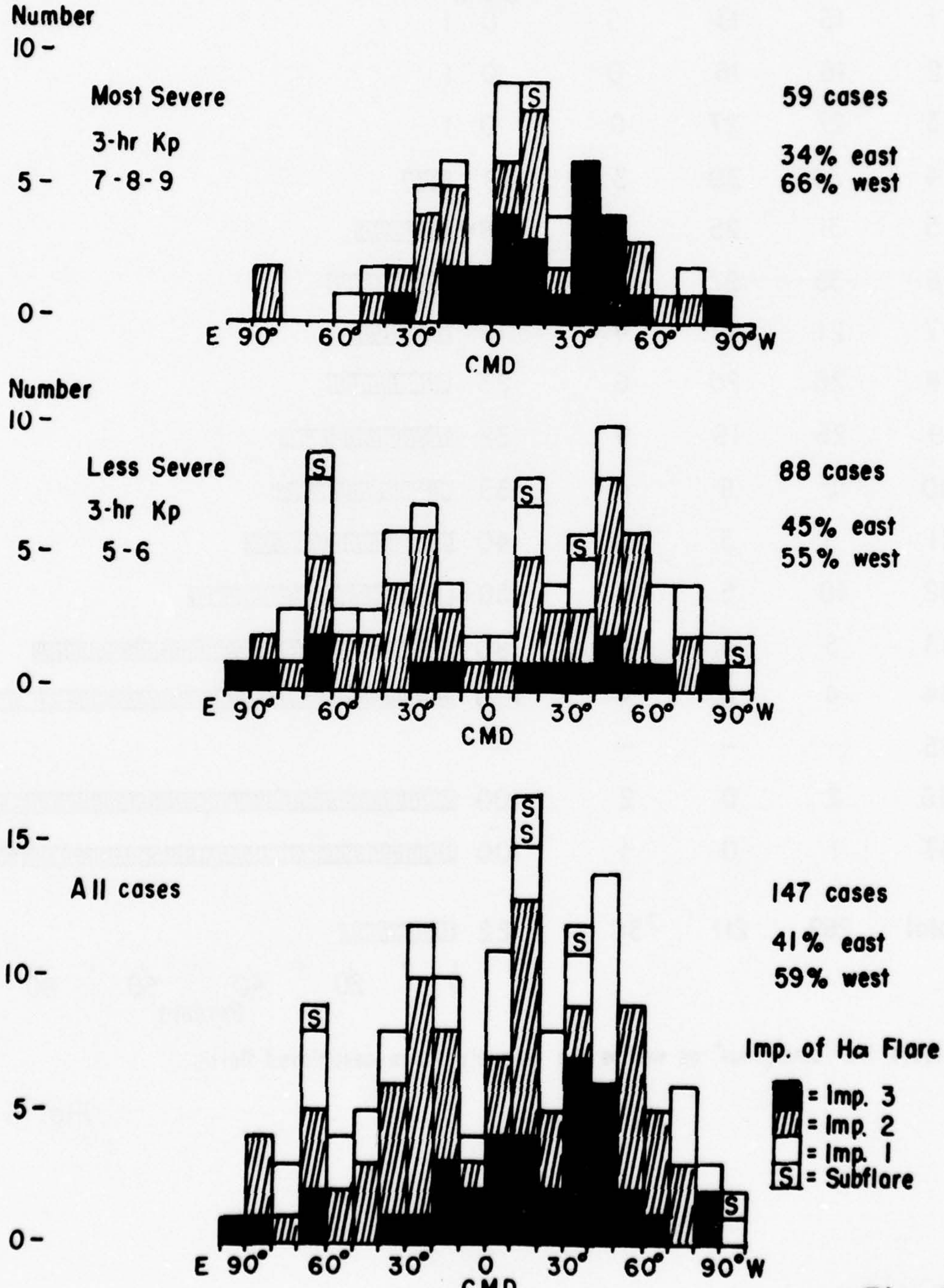
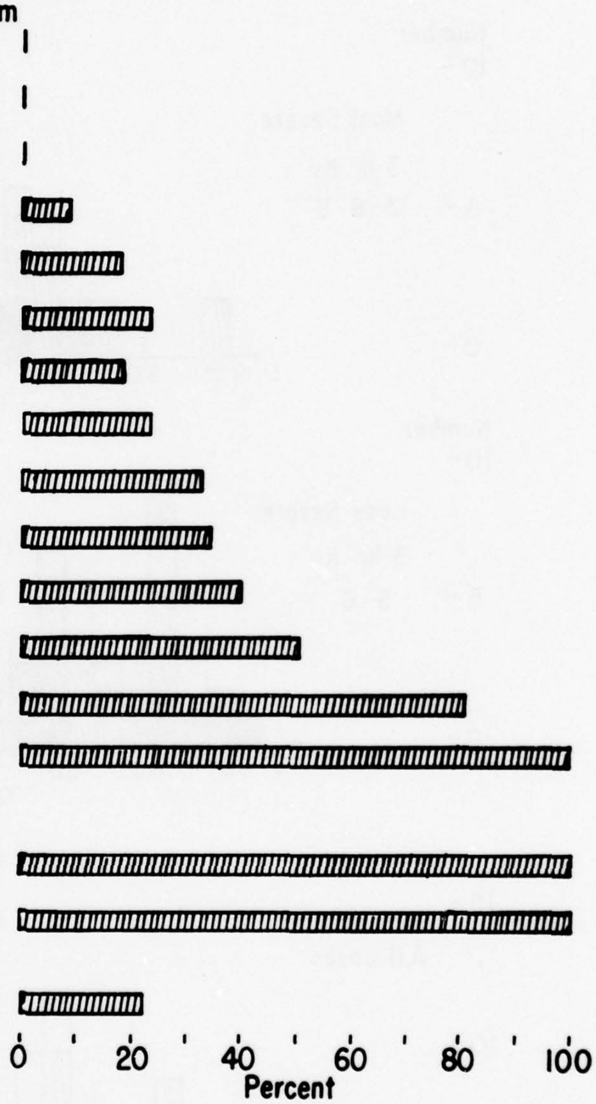


Fig. 4

Number and Percent of "Major" Flares with Different Values of the Comprehensive Flare Index (CFI), Associated with Geomagnetic Storms with Maximum 3-Hourly Kp ≥5, 1965-1968.

CFI	Number of "Major" Flares (1965-1968) Total	Without Storm	Storm Associated	Percent with Storm
1	13	13	0	0
2	16	16	0	0
3	27	27	0	0
4	33	30	3	9
5	31	25	6	18
6	35	27	8	23
7	21	17	4	19
8	26	20	6	23
9	28	19	9	32
10	12	8	4	33
11	5	3	2	40
12	10	5	5	50
13	5	1	4	80
14	4	0	4	100
15	–	–	–	–
16	2	0	2	100
17	1	0	1	100
Total	269	211	†58	22



†Includes the "ambiguous" as well as the uniquely storm-associated flares.

Fig. 5

TABLE 1

SUMMARY OF PRINCIPAL GEOMAGNETIC STORMS AND ASSOCIATED SOLAR DATA 1955-1957

Storm Rank	Storm Date	Max. 3-hr. K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1955								
24	Jan.8	5	Flare	Jan.6^d 1725	N18	E30	2	≥7	1^d1^h
2(a)	Jan.18	8	Flare	Jan.16^d 2130	N33	W41	3	≥9	1^d3^h
27	Feb.4	5	Flare(?)-Seq.(?)	Meter-λ radio event Feb.2^d0245.					
11	Feb.28	6	Flare-Seq.	Feb.25^d 1320	N24	E20	2	≥2	2^d11^h
9	Mar.6, 9	6	Prob.	No appropriate prior flare; not clearly sequential.					
10	Mar.22	6	Seq.	No appropriate prior flares.					
7	Mar.30	6	Seq.	" " " "					
28	Apr.24	5	Seq.(?)	" " " "					
3	Apr.27	8	Seq.	" " " "					
8	May 6	6	Prob.	" " " " and not clearly sequential.					
5	May 25	7	Flare-Seq.	May 23^d 1250	N24	W27	1	7	2^d2^h
18	May 27	5	Flare(?)	Strong metric burst May 25^d0227, but no Hα patrol.					
19	Jun.6	5	Seq.(?)	No appropriate prior flares.					
26	Jun.22	5	Flare-Amb.-Seq.	(b)Jun.18^d 1905	S22	W21	3	12	3^d15^h
29	Jul.2	5	Seq.(?)	No appropriate prior flares.					
15	Aug.3, 6	5	Seq.	" obviously appropriate prior flare.					
14	Aug.28	6	Prob.	No obviously appropriate prior flare and storm is not sequential.					
20	Sep.1	5	Seq.	No appropriate prior flares.					
21	Sep.12	5	Seq.-Flare(?)	Type II burst Sep.10^d0509. No Hα flare patrol. Storm is in sequence.					
4	Sep.29	7	Seq.	No appropriate prior flare.					

(a) Earlier start on Jan.17 can be associated with flares Jan. 13-15.

(b) Flare, imp.3, June 18^d1218 probably also contributed.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1955								
13	Oct.5	6	Seq.(?)	No appropriate prior flare. Storm is possibly sequential.					
6	Oct.25	6	Seq.	No appropriate prior flares.					
17	Oct.31	5	Flare-Seq.	Oct.28^d 1955	S25	E25	2	≥5	2^d16^h
22	Nov.4	5	Seq.	No appropriate prior flares					
31	Nov.12	5	Flare	(c)Nov.9^d 1319	N25	E60	1	≥7	2^d18^h
16	Nov.15	5	Flare	Nov.12^d 1116	N27	E27	3	≥8	2^d19^h
12	Nov.18	6	Flare-Amb.	Nov.15^d 0428	N26	W09	1+	6	2^d23^h
1	Nov.19	8	Flare(?)	SWF and cm burst Nov.18^d~0240; no Hα flare patrol.					
23	Dec.1	5	Flare(?)-Seq.	SWF Nov.28^{d}2230 and Type II burst Nov.30^{d}0539. No flare patrol.					
25	Dec.24	5	Seq.	No appropriate prior flares.					
30	Dec.26	5	Seq.-Flare	SID and radio freq. event Dec.25^{d}1432. No Hα flare patrol.					
	1956								
41	Jan.1	5	Seq.-Flare	(1955) Dec.29^d 0045	N16	E59	1+	≥7	3^d12^h
21	Jan.10	6	Prob.	No appropriate prior flares; not sequential.					
20	Jan.17	6	Flare-Amb.	(d)Jan.14^d 0137	N28	E70	1+	≥6	3^d22^h
29	Jan.21	6	Flare-Amb.-Seq.	(e)Jan.19^d 0535	N22	E19	3	4	2^d11^h
22	Jan.23	6	Seq.(?)	No appropriate prior flares.					

(c) Other flares in same center of activity, Nov.9-11, may have contributed to the storm.
(d) Other flares imp. 1 and 2 in same center of activity, Jan. 15 and 16.
(e) Type II burst Jan. 19^{d}0026; no Hα flare patrol.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1956								
24	Jan.27	6	Seq.- Flare-Amb.	(f)Jan.23^d 1620	N22	W48	2	≥5	3^d17^h
37	Feb.11	5	Flare	Feb.10^d 2110	N22	E90	3	≥8	0^d21^h
3	Feb.25	8	Flare	Feb.23^d 0331	N23	W80	3	≥13	2^d0^h
32	Feb.27	5	Seq.	No appropriate prior flares.					
9	Mar.2	7	Flare-Amb.	(g)Feb.29^d 2220	S29	W24	3	≥11	2^d1^h
30	Mar.10	6	Seq-Flare(?)	Type II burst Mar.8^d0321; No Hα flare patrol.					
13	Mar.20/21	7	Flare-Seq.	Mar.20^d 0235	S17	W04	2	≥9	0^d22^h
28	Mar.24	6	Seq.	No appropriate prior flares.					
23	Mar.28	6	Seq.	No appropriate prior flares.					
42	Apr.2	5	Flare	Mar.31^d 1350	N30	W80	1	≥6	1^d18^h
11	Apr.21	7	Flare	Apr.18^d 1247	N20	W16	2+	≥7	2^d23^h
1	Apr.26	9	Flare-Amb.	(h)Apr.26^d 0200	N14	W08	1	8	0^d19^h
8	Apr.28	8	Flare	Apr.27^d 2050	N16	W27	1+	≥7	0^d21^h
18	Apr.30	6	Prob.	No appropriate prior flares.					
15	May 11	7	Flare-Amb.-Seq.	May 8^d 1300	S27	E80	2	≥8	3^d10^h
2	May 15/16	8	Flare	(i)May 11^d 1810	S15	W08	2	≥4	3^d6^h
25	May 20	6	Flare-Amb.	(j)May 17^d 2230	S24	W18	3	≥6	2^d08^h

(f) Other possibly appropriate flares in same center of activity, Jan. 23 and 25.

(g) Another appropriate flare Mar. 1^d1730.

(h) Type II burst Apr.25^d2348; No flare patrol. Another possibly appropriate flare Apr.24^d0430.

(i) Another flare, imp.2, in same center of activity, on May 14^d 0245 contributes to the second start and increased severity of storm.

(j) Additional flares May 17-18.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1956								
10	May 23	7	Flare-Seq.	(k) May 21^d 0310	S23	E20	1	5	2^d6^h
14	Jun.23	7	Flare-Amb.-Seq.	(l) Jun.22^d 1525	S20	W15	2	≥8	1^d03^h
43	Jun.26	5	Flare-Seq.	Jun.24^d 1300	N30	W90	1-	≥7	1^d17^h
44	Jul.13	5	Seq.	No appropriate prior flares.					
19	Jul.23	6	Flare-Seq.	Jul.22^d 1624	N29	W54	2	≥8	0^d20^h
39	Aug.9	5	Flare-Seq.	Aug.8^d 1128	N20	E48	2	≥6	0^d23^h
34	Aug.11	5	Flare-Amb.-Seq.	(m) Aug.9^d 0141	N21	E48	2	≥7	1^d23^h
31	Aug.21	6	Flare-Amb.-Seq.	(n) Aug.19^d 0120	S21	E67	1	≥6	2^d4^h
5	Aug.23	8	Flare	Aug.21^d 1945	S20	W17	2	≥9	1^d12^h
45	Aug.31	5	Flare-Amb.	(o) Aug.28^d 2220	N17	E51	2+	≥7	2^d12^h
6	Sep.2	8	Flare	Aug.31^d 1226	N15	E15	3	≥12	1^d14^h
7	Sep.8	8	Flare-Amb.	(p) Sep.7^d 1245	S16	E42	2	≥7	0^d22^h
26	Sep.20	6	Flare-Seq.	Sep.17^d 1942	S20	W17	2+	≥8	2^d9^h
36	Oct.2	5	Flare-Amb.	(q) Oct.1 0755	N45	W48	3	≥3	0^d21^h
33	Oct.20	5	Seq.	No appropriate prior flares.					
16	Oct.26	7	Seq.	Flares on Oct.22 and 23 do not see appropriate.					

(k) Additional flare in same region May 21^d0647.
(l) Additional flare June 20^d1958
(m) Additional flares imp. 2 on Aug. 8 and 9.
(n) Another appropriate flare Aug. 18^d0814.
(o) SWF imp.3+ Aug.30^d0157, no flare patrol; also another appropriate flare Aug.28^d1520.
(p) Additional appropriate flares on Sep. 5-7.
(q) Also a flare on Oct. 1^d0515 may have contributed.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1956								
12	No.9	7	Flare	Nov.7^d 1119	S17	E32	3+	≥9	2^d9^h
4	Nov.14	8	Flare	(r)Nov.13^d 0157	N28	W58	3-	≥8	1^d0^h
35	Nov.20	5	Flare-Amb.	(s)Nov.17^d 0426	S19	W73	1	≥8	3^d05^h
27	Nov.22	6	Flare	Nov.20^d 1002	S15	W56	3	≥12	2^d02^h
17	Nov.25	7	Flare	Nov.22^d 1312	S15	W84	2	≥11	2^d22^h
46	Nov.27	5	Seq.	No appropriate prior flare.					
40	Dec.25	5	Flare-Seq.	Dec.21^d 1555	N17	E66	1-	6	3^d16^h
38	Dec.27	5	Flare	Dec.26^d 1401	S17	W11	2	12	1^d1^h
47	Dec.30	5	Flare	Dec.29^d 0040	N16	E59	1+	≥10	1^d6^h
	1957								
55	Jan.2	5	Flare(?)	Incomplete solar data.					
41	Jan.9	5	Flare-Amb.	(t)Jan.7^d 1830	N20	W65	2+	10	1^d18^h
6	Jan.21	9	Flare	Jan.20^d 1100	S30	W18	3	≥6	1^d02^h
32	Jan.29	6	Prob.	No appropriate prior flare.					
29	Feb.3	6	Flare-Amb.	(u)Feb.1^d 1525	N21	W32	2	4	2^d0^h
26	Feb.12	6	Flare-Amb.	(v)Feb.10^d 0819	S23	W72	2	6	2^d10^h

(r) Flare Nov.14^d1430 also a contributor.
(s) Additional appropriate flares on Nov.18^d0845 & Nov.19^d0834.
(t) Additional appropriate flare on Jan.6^d1822.
(u) Another appropriate flare Jan.31^d0358.
(v) Another possibly appropriate flare Feb.8^d1550.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1957								
40	Feb.21	5	Prob.	No appropriate prior flares.					
16	Feb.23	7	Flare	Feb.21^d 1605	N20	w33	3+	6	2^d2^h
8	Mar.1	8	Flare	Feb.28^d 0005	N18	W35	3	9	1^d16^h
14	Mar.10	7	Prob.	No appropriate prior flares; not sequential.					
30	Mar.15	6	Seq.	No significant prior flares.					
49	Mar.21	5	Flare-Seq.	Mar.20^d 1600	S20	W53	2	6	0^d20^h
36	Mar.25	6	Prob.	No appropriate prior flares; not sequential.					
18	Mar.26	7	Flare	Mar.24^d 1848	S14	W20	2	8	1^d16^h
9	Mar.29	8	Flare	Mar.27^d 0415	N12	E18	2	8	1^d23^h
59	Apr.3	5	Flare-Amb.	(w)Apr.2^d 1959	N25	W90	1	8	0^d21^h
31	Apr.5	6	Flare	Apr.3^d 0825	S14	W60	3	≥8	2^d2^h
17	Apr.9	7	Flare	Apr.8^d 0342	S22	E50	1+	7	1^d2^h
39	Apr.15	6	Flare	Apr.12^d 1850	S25	W73	2	10	3^d2^h
10	Apr.17	8	Flare-Amb.	(x)Apr.15^d 1410	N25	E90	2	11	1^d21^h
46	Apr.24	5	Flare-Amb.	(y)Apr.22^d 1420	N26	E02	2	7	1^d10^h

(w) Another appropriate flare Apr.02^{d}0255.
(x) Additional contributing flares Apr.16^{d}1040, Apr.17^{d}2000.
(y) Additional appropriate flares include Apr.22^{d}0548 and Apr.20^{d}1017.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr Kp	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt of Storm
	1957								
53	Apr.26	5	Flare-Amb.	(z)Apr.24^d 0039	S12	W18	2	≥5	1^d23^h
54	May 8	5	Flare-Amb.	(aa)May 8^d 0452	S26	E43	1+	≥5	0^d17^h
44	May 26	5	Flare	May 24^d 1603	N10	W50	2	6	1^d8^h
50	May 30	5	Seq.	No significant prior flares.					
28	Jun.3	6	Flare-Amb.	(bb)Jun.1^d 2329	S25	W44	2	≥8	1^d5^h
51	Jun.17	5	Flare-Amb.	(cc)Jun.15^d 0730	S18	E60	2	≥5	2^d14^h
12	Jun.25	7	Flare-Amb.	(dd)Jun.22^d 0236	N23	E12	2	6	2^d22^h
7	Jun.30	8	Flare-Amb.	(ee)Jun.28^d 1223	N12	E21	2	7	1^d17^h
11	Jul.2	8	Flare-Amb.	(ff)Jul.1^d 0958	S23	W76	1+	≥5	0^d23^h
19	Jul.5	7	Flare	Jul.3^d 0712	N12	W41	3+	≥11	1^d18^h
47	Jul.19	5	Flare-Amb.	(gg)Jul.17^d 0112	N11	E30	1+	8	2^d12^h
37	Jul.22	6	Flare-Seq.	Jul.21^d 0633	N30	E15	2	9	0^d22^h
38	Aug.3	6	Flare-Amb.	(hh)Aug.2^d 1432	N26	E32	1	7	1^d0^h
34	Aug.6	6	Flare	Aug.3^d 1721	N26	E17	1	7	2^d12^h

(z) Additional appropriate flares include Apr.23^{d}0620 and 0122, and Apr.22^{d}1420.
(aa) Additional appropriate flares, May 7^{d}1016; May 6^{d}2328.
(bb) " " " Jun.1^{d}1252; Jun.2^{d}1512.
(cc) " " " Jun.15^{d}0620 and 0312.
(dd) " " " Jun.21^{d}2210; Jun.24^{d}0838.
(ee) " " " Jun.28^{d}0658.
(ff) " " " Jun.30^{d}0924.
(gg) " " " Jul.16^{d}1742.
(hh) " " " Aug.1^{d}1352.

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Ha Imp.	CFI	Δt to Storm
	1957								
33	Aug.12	6	Flare-(ii) Amb.	Aug.10^d	N26	W71	1	11	2^{d}3^h
60	Aug.20	5	Seq.	No appropriate prior flares.					
20	Aug.29	7	Flare-(jj) Amb.	Aug.28^d 2010	S28	E30	2+	9	0^{d}23^h
21	Aug.31	7	Flare-(kk) Amb.	Aug.30^d 0620	N26	E22	2	≥7	1^{d}6^h
5	Sep.2	9	Flare	Aug.31^d 1257	N25	W02	3	15	1^{d}14^h
3	Sep.4	9	Flare	Sep.3^d 1412	N23	W30	3	11	0^{d}23^h
2	Sep.13	9	Flare-(ll) Amb.	Sep.11^d 0240	N13	W02	3	15	1^{d}23^h
13	Sep.21	7	Flare-(mm) Amb.	Sep.18^d 1303	N21	E07	3	9	2^{d}21^h
1	Sep.22	9	Flare-(nn) Amb.	Sep.21^d 1330	N10	W06	3	14	1^{d}0^h
4	Sep.29	9	Flare	Sep.26^d 1907	N22	E15	3	11	2^{d}5^h
52	Oct.13	5	Flare-(oo) Amb.	Oct.11^d 1505	S24	E70	1	6	1^{d}9^h
25	Oct.14	6	Flare-(pp) Amb.	Oct.12^d 0900	S25	E62	2	≥6	1^{d}19^h
23	Oct.21	7	Flare-(qq) Amb.	Oct.20^d 1637	S26	W40	3+	14	1^{d}6^h
22	Nov.6	7	Flare-Seq.	Nov.5^d 1205	S24	W54	2	≥10	1^{d}6^h
43	Nov.8	5	Flare-Seq.	Nov.6^d 0834	S28	W67	2	≥9	1^{d}21^h
48	Nov.17	5	Seq.	No significant prior flares.					

(ii) Additional appropriate flares, Aug.9^{d}1330 and 0619.
(jj) " " " Aug.28^{d}0913.
(kk) " " " Aug.29^{d}0545, Aug.28^{d}2010.
(ll) " " " Sep.12^{d}0703 and 1510.
(mm) " " " Sep.18^{d}1722, Sep.19^{d}0350.
(nn) " " " Sep.21^{d}1440 and 0415.
(oo) " " flare Oct.10^{d}1630.
(pp) " " flares Oct.12^{d}0859, Oct.11^{d}1505.
(qq) " " flare Oct.20^{d}0938

TABLE 1 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1957								
42	Nov.25	5	Flare	Nov.22^d 0404	N31	W28	2	11	2^d23^h
15	Nov.26	7	Flare	Nov.24^d 0848	S13	E36	3	≥13	1^d18^h
35	Dec.1	6	Flare	Nov.29^d 0045	N41	E63	3+	4	2^d2^h
45	Dec.5	5	Flare-(rr) Amb.-Seq.	Dec.3^d 1300	S19	W49	2	6	1^d12^h
57	Dec.7	5	Flare-(ss) Amb.	Dec.6^d 0347	N15	E45	2	7	1^d4^h
27	Dec.11	6	Flare-(tt) Amb.	Dec.9^d 0157	S17	E09	1	6	2^d1^h
56	Dec.15	5	Flare-(uu) Amb.-Seq.	Dec.14^d 1245	N18	E78	2+	≥11	0^d20^h
58	Dec.19	5	Flare-(vv) Amb.	Dec.18^d 0605	N17	E20	2	9	1^d3^h
24	Dec.31	6	Flare-Seq.	Dec.28^d 2229	N25	W50	2	≥10	2^d3^h

(rr) Additional appropriate flare, Dec.2^d1055.
(ss) " " " Dec.5^d1014.
(tt) " " " Dec.8^d0814.
(uu) " " " Dec.13^d0229.
(vv) " " flares, Dec.17^d1532 and 0734.

TABLE 2

Summary of Principal Geomagnetic Storms and Associated Solar Data

1965-1968

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1965								
10	Jan.22	6	Prob.-Seq.	No appropriate prior flares.					
4	Feb. 6	6	Flare	Feb.5^d 1750	N08	W25	2	9	0^d21^h
12	Feb.23	5	Seq.	No appropriate prior flares.					
6	Mar. 2	6	Seq.	"	"	"	"		
8	Mar.22	5	Seq.	"	"	"	"		
1	Apr.17	8	Flare-Seq.	Apr.16^d 0942	N04	E20	1-2	≥ 2	1^d4^h
9	May 4	5	Seq.-Flare	May 1^d 1427	N28	E85	S	5	3^d9^h
14	May 16	5	Seq.	No appropriate prior flares.					
2	Jun.15	7	Flare	Jun.13^d 0257	N23	W03	1	≥ 5	2^d9^h
11	Jul. 6	5	Seq.?	No appropriate prior flares					
15	Jul.27	5	Seq.	"	"	"	"		
3	Aug.18	6	Seq.	No appropriate prior flares					
7	Sep.15	5	Seq.	"	"	"	"		
5	Sep.27	6	Seq.	"	"	"	"		
16	Oct. 7	5	Seq.	"	"	"	"		
13	Nov. 5	5	Seq.	"	"	"	"		
	1966								
17	Jan.20	5	Flare-Amb.	(a) Jan.17^d 1029	N19	E27	2b	10	2^d16^h
18	Feb.22	5	Prob.	No appropriate prior flares; not sequential.					
5	Mar.13	7	Prob.	No appropriate prior flares; not sequential.					

(a) Additional appropriate flares: Jan.16^{d}1845, Jan.18^{d}2253.

TABLE 2 (con't)

Storm Rank	Storm Date	Max. 3-hr Kp	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1966								
24	Mar.19	5	Flare-Amb.	(b)Mar.16^d 1603	N18	E60	1b	8	2^d10^h
4	Mar.23	7	Flare	(c)Mar.20^d 0928	N21	E25	2b	≥11	2^d21^h
14	Mar.26	6	Flare-Amb.	(d)Mar.24^d 0225	N20	W42	2n	12	2^d7^h
7	Mar.27	7	Flare-Amb.	(e)Mar.25^d 0145	N20	W54	2n	10	2^d17^h
22	Apr. 1	5	Flare	Mar.30^d 1241	N28	E50	2n	14	2^d0^h
2	May 25	7	Flare-Amb.	(f)May 24^d 1413	N12	E19	Sn	5	1^d9^h
8	May 31	6	Flare	May 28^d 1532	N15	W40	2b	10	2^d12^h
25	Jun.24	5	Seq.	No appropriate prior flares.					
11	Jul. 8	6	Flare	Jul.7^d 0025	N35	W48	2b	13	1^d21^h
29	Aug.18	5	Seq.	Flare association is not convincing.					
12	Aug.29	7	Flare	Aug.26^d 1805	N23	E22	2n	≥6	2^d19^h
3	Aug.30	7	Flare	Aug.28^d 1523	N22	E05	3b	16	1^d20^h
23	Sep. 1	5	Flare	Aug.31^d 0037	N21	W30	2b	10	1^d6^h
1	Sep.3	9	Flare	Sep.2^d 0542	N24	W56	3b	13	$\sim 1^d$
21	Sep.5	5	Flare	Sep.4^d 0407	N21	W87	3n	14	1^d16^h
9	Sep.8	6	Seq.	No appropriate prior flares.					
28	Sep.14	5	Seq.-Flare	Sep.12^d 0925	N12	E90	1n	≥5	2^d6^h

(b) Additional appropriate flare: Mar.16^d1918.
(c) Includes flare development Mar.20^d1011, N15 E08.
(d) Additional appropriate flare: Mar. 23^d2248.
(e) " " " : Mar. 26^d1843.
(f) Flares on May 25^d1042 and 1530 probably were contributors to this storm.

TABLE 2 (con't)

Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1966								
27	Sep.25	5	Seq.	No appropriate prior flares.					
10	Oct.4	6	Seq.	"	"	"	"		
13	Oct.15	6	Flare	Oct.13^d 0430	N21	E66	2n	≥9	2^d6^h
15	Oct.30	5	Seq.	No appropriate prior flares.					
26	Nov.28	5	Seq.	"	"	"	"		
19	Nov.30	5	Seq.	"	"	"	"		
20	Dec.4	5	Prob.	Flare association is not convincing.					
30	Dec.13	5	Seq.-Flare	Dec.10^d 2305	N21	E90	2n	7	2^d2^h
6	Dec.14	7	Seq-Flare-Amb.	(g)Dec.11^d 0537	N18	E77	1n	≥4	3^d7^h
16	Dec.25	5	Seq.	No appropriate prior flares.					
	1967								
8	Jan.7	7	Flare	Jan.5^d <0017	S26	E34	2f	2	2^d7^h
2	Jan.13	8	Flare	(h)Jan.11^d 0137	S24	W45	3b	5	2^d11^h
11	Feb.7	6	Flare	Feb.4^d 1641	N11	E40	2b	≥8	3^d0^h
3	Feb.15	8	Flare	Feb.13^d 1747	N21	W11	3b	≥8	2^d6^h
16	Mar.18	6	Prob.	No appropriate prior flares; not sequential.					
28	Apr.1	5	Flare	Mar.30^d 0851	N24	W49	2n	≥7	2^d0^h
29	Apr.4	5	Seq-Flare	Apr.1^d 1410	N21	W80	1b	7	2^d13^h
19	Apr.22	5	Prob.	No appropriate prior flare; not sequential.					
5	May 1	7	Prob.	No appropriate prior flare; not sequential.					

(g) Flare Dec.13^d2300 was probably a contributor.
(h) Flares on Jan.11^d2016 and Jan.12^d0231 may have been contributors to the storm.

TABLE 2 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp	CFI	Δt to Storm
	1967								
1	May 25	9	Flare	May 23^d 1802	N27	E25	3b	16	1^d18^h
7	May 27	7	Flare	May 25^d 1039	N22	W06	1b	12	2^d9^h
9	May 30	7	Flare	May 28^d 0529	N28	W32	3b	13	2^d9^h
4	Jun.5	8	Flare	Jun.3^d 0226	N23	E12	1n	7	2^d17^h
14	Jun.25	6	Flare	Jun.23^d 0037	N15	E32	1n	9	2^d2^h
24	Aug.11	5	Flare	Aug.9^d 1758	S24	E32	2b	4	1^d11^h
26	Aug.16	5	Seq.	No appropriate prior flares.					
23	Sep.1	5	Seq.-Flare	Aug.29^d 1330	N22	W46	2b	7	2^d14^h
20	Sep.13	5	Seq.	No appropriate prior flares.					
27	Sep.18	5	Flare-Amb.	(i) Sep.17^d 1050	N18	W38	1n?	6	1^d9^h
6	Sep.19	7	Flare	Sep.18^d 2316	N16	W60	2b	8	0^d20^h
17	Sep.28	5	Seq.	No appropriate prior flares.					
18	Oct.9	5	Seq.	"	"	"	"		
21	Oct.28	5	Flare	Oct.26^d 0608	N10	W38	1b	6	2^d0^h
25	Nov.3	5	Flare	Nov.2^d 0852	S18	W02	2b	12	1^d1^h
15	Nov.11	6	Prob.	Prior Type II and Type IV but flare unknown.					
12	Dec.1	6	Prob.	Nov.28^d 1530 (Flare association is not convinging)	S20	W06	Sn	≥4	2^d12^h
22	Dec.5	5	Seq.	No appropriate prior flare.					

(i) Additional appropriate flare Sep.17^d0353,

TABLE 2 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1967								
13	Dec.18	6	Flare	Dec.16^d 0247	N23	E66	3n	9	2^d3^h
10	Dec.31	6	Flare-Amb. (j)	Dec.29^d 0106	S15	W22	1b	3	2^d2^h
	1968								
13	Jan.2	6	Seq.	No appropriate prior flares.					
32	Feb.2	5	Seq-Flare	Jan.31^d 2129	N15	W18	2n	2	1^d11^h
6	Feb.10	6	Flare-Amb. (k)	Feb.8^d 1404	N32	W15	Sf	4	2^d2^h
28	Feb.15	5	Prob.(Seq?)	No convincing prior flare.					
25	Feb.18	5	Flare	Feb.15^d 1450	S14	W11	1b	8	2^d17^h
12	Feb.20	6	Flare	Feb.17^d 0252	N17	W47	1b	6	$3d5h$
20	Feb.27/28	5	Seq.	No appropriate prior flare.					
15	Mar.14	6	Seq.	No appropriate prior flare.					
23	Mar.30	5	Seq.-Flare(?)	Mar.27^d 1757	S12	W42	2b	≥7	2^d11^h
5	Apr.5	7	Seq.	No appropriate prior flare.					
24	Apr.13	5	Seq.	" " " "					
16	Apr.25	6	Seq.	" " " "					
4	May 7	7	Flare	May 3^d 2123	N18	E49	1b	9	3^d3^h
18	May 10	6	Seq-Flare	May 8^d 1415	N23	E58	Sf	5	2^d1^h
27	May 20	5	Seq.	No convincing prior flare.					
22	Jun.10 (0^h)	5	Flare	Jun.9^d 0025	N14	E38	2n	6	1^d0^h

(j) Additional appropriate flare Dec.29^d0047.
(k) " " " Feb.8^d1402.

TABLE 2 (con't)

Storm Rank	Storm Date	Max. 3-hr K_p	Class. of Storm	Associated Flare Data: Date	Lat.	Long.	Hα Imp.	CFI	Δt to Storm
	1968								
3	Jun10 (22^h)	8	Flare	Jun.9^d 0830	S14	W09	3b	14	1^d13^h
19	Jul.9	5	Flare	Jul.8^d 1708	N13	W58	3b	17	1^d04^h
17	Jul.13	6	Flare	Jul.12^d 1348	N11	W20	2n	8	1^d03^h
10	Aug.16	6	Seq.-Flare	Aug.14^d 1327	N13	W80	1b	7	2^d21^h
30	Aug.23	5	Flare	Aug.21^d 0146	S16	W43	1n	8	$2^d\ 16^h$
9	Sep.6/7	6	Flare	Sep.4^d 0031	N13	W14	1n	9	2^d14^h
11	Sep.12	6	Seq.	No convincing prior flare.					
8	Oct.2	6	Flare	Sep.29^d 1617	N17	W51	2b	12	2^d08^h
7	Oct.12	6	Seq.	No appropriate prior flare.					
14	Oct.29	6	Flare	Oct.27^d 1232	S17	E17	2n	12	1^d21^h
2	Oct.30	8	Flare-Amb.	(1)Oct.29^d 1222	S16	W12	2b	14	1^d11^h
1	Nov.1	8	Flare	Oct.30^d 2340	S14	W37	3b	13	1^d10^h
21	Nov.4	5	Flare	Nov.2^d 0940	S15	W65	2b	12	1^d20^h
29	Nov.16	5	Flare	Nov.13^d 0016	N18	W15	Sb	4	3^d9^h
26	Dec.5	5	Flare	(m)Dec.2^d 2202	N19	E80	3n	≥ 9	2^d9^h
31	Dec.24	5	Flare-Amb.	(n)Dec.21^d 1730	N19	E80	2n	3	3^d5^h

(1) Additional appropriate flares: Oct.29^d1515 & Oct.27^d1232.
(m) Additional flare, Dec.2^d2115.
(n) Flares on Dec.23^d1112 and Dec.24^d0153 probably were contributors to the storm.

TABLE 3

Number and Percent of Geomagnetic Storms in Different Classifications and of Different Severities, 1955-1957 and 1965-1968

1955-1957

Max. 3-hr. K_p	9	8	7	6	5	Total
			Number			
*Flare-associated	7	14	20	22	36	99
+Sequential	-	1	2	10	17	30
Problem	-	-	1	7	1	9
Total	7	15	23	39	54	138
			Percent			
*Flare-associated	100	93	87	56	67	71
+Sequential	-	7	9	26	31	22
Problem	-	-	4	18	2	7
Total	100	100	100	100	100	100

1965-1968

Max. 3-hr. K_p	9	8	7	6	5	Total
			Number			
*Flare-associated	2	7	11	15	18	53
+Sequential	-	-	3	12	29	44
Problem	-	-	2	4	4	10
Total	2	7	16	31	51	107
			Percent			
*Flare-associated	100	100	69	48	35	50
+Sequential	-	-	19	39	57	41
Problem	-	-	12	13	8	9
Total	100	100	100	100	100	100

*Includes classifications "flare-ambiguous" and "flare-sequential."

+Includes classification "sequential-flare."